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Students' Discourse in Learning Mathematics with Self-Regulating Strategies

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Abstract

The purpose of this study was to investigate students' discourse in learning mathematics while engaging with the self-regulated learning (SRL) strategies, particularly the cognitive learning strategies. Participants in this study were a group of Year 9 students in a secondary school in the East of England.The data consisted of video recording of students' group work sessions at the end of the mathematics lesson. The sessions were video recorded, the original work of the students was collected and field notes were taken. This was followed by the data analysis, whereby the data was analysed for the effectiveness and productiveness of students' communication and their engagement with the cognitive learning strategies. The Sfard &Kieran's discourse analysis model was employed to analyse students' communication and Pintrich's SRL strategies framework was used to analyse students' cognitive learning strategies. The findings from this study showed that students were involved fully in an effective and productive discourse and engaged with the components of cognitive learning strategies.

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Keywords: Self-regulating strategies, cognitive learning strategies, discourse analysis, secondary mathematics

1. Introduction

The importance of studies on self-regulating learning (SRL) emerged in response to the question of how can student become in charge of their own learning. Students who self regulate their learning are academically more successful and some teaching experiments have found that students can actually be taught to self regulate. A number of models have been proposed by scholars and educators to describe the processes of SRL, however, for the purpose of this study, the study employed the Pintrich's (1999) model which focuses solely on the cognitive learning strategies: rehearsal strategies, elaboration strategies, and organisational strategies.

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The study also introduced the component of discourse analysis (Sfard & Kieran, 2001) to observe the students' interactions while working together in a group. In this study, students' interaction is one of the focuses of our investigations. Current studies show that students have difficulties communicating mathematically in group tasks (Kieran, 2001; Sfard, 2001; Sfard & Kieran, 2001). In addition, from the cognitive perspective we have to examine whether or not all members in a group participated in learning mathematics, even though they have solved a mathematical task (Ryve, 2004). In this study, we will examine the effectiveness and productiveness (Sfard & Kieran, 2001) of the communication through the components of discourse analysis, namely focal analysis and preoccupational analysis. In this study we are interested in the observations of SRL as it emerges through a classroom based activity in mathematics and we propose the use of discourse analysis techniques to gain insight in the social interaction of the students while self-regulating and on how this social interaction impact on the presence of SRL and the success in solving the mathematical task. Thus, our research question is: What is the relation between engagement in self-regulating learning strategies and effective discourse in a mathematics group activity?

2. Theoretical background

The mathematical communication framework for this study was designed to investigate and examine students' interactions and students' SRL strategies, particularly cognitive learning strategies in the context of a group solving mathematical tasks. This two-dimensional theoretical framework is a combination of Sfard and Kieran's (2001) discourse analysis framework and Pintrich's (1999) SRL model, particularly the component of cognitive learning strategies. The mathematical communication framework is shown in Fig.1 below. Three indispensable focal analysis components are *pronounced focus*, *attended focus,* and *intended focus*. These components of focal analysis analyse whether students are involved in a conversation that is coherent, that is, the respondent is responding to the same thing the speaker has been addressing to. Pronounced focus refers to two or more people referring to *something* (same word) when they interact. Attended focus includes "not just the image a person perceives (or imagines), but also the attending procedure she is performing while scanning this image, mediates between the two other components" (Sfard & Kieran, 2001, p. 53). Intended focus is "described as a cluster of experiences evoked by the other focal components plus all the statements a person would be able to make on the entity question" (ibid., 2001, p. 53). The primary tool for the preoccupational analysis is the interactivity flowchart, which aims to examine in-depth the mathematical communication amongst the interlocutors within themselves and between themselves.

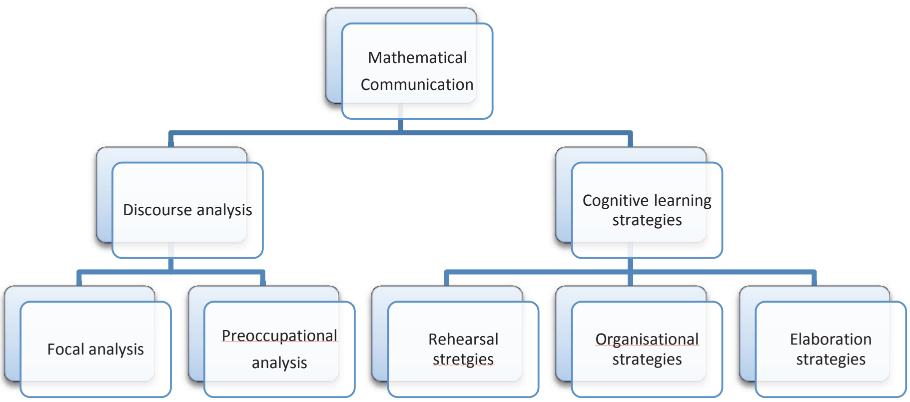

Fig.1. The mathematical communication framework

The inclusion of the cognitive learning strategies as a component in the mathematical communication framework is to examine students' mathematical learning in the classroom. The cognitive learning strategies consist of three elements: rehearsal strategies, elaboration strategies, and organisational strategies. The rehearsal strategies include three elements where the participants: (1) read the problem and associate it with the relevant mathematics topic/content, (2) evoke prior knowledge relevant to the problem, and (3) highlight or underline important words or phrases. The elaboration strategies consist of three elements where the participants: (1) break down the problem into parts, (2) refer to previously seen problems, and (3) discuss the problem to clarify goals. The organisational strategies include four elements where the participants: (1) gather important information or facts from the problem that can help to solve the problem, (2) discuss and confirm the goals to achieve, (3) evaluate (a variety of) strategies, and (4) implement one chosen strategy. If a learner employs any of the elements of a component, and influences others in the group, the group is observed to engage with that particular component.

3. The study

The study lasted for six months and involved a group of four Year 9 students aged between fourteen and fifteen years old in one secondary school in the East of England. The main data of the study consist of video recordings of the students engaging in the mathematics tasks set by the teacher at the end of each lesson (the final 20 – 25 minutes at the end of the one hour lesson). As supplementary data, field notes were taken during the lessons and the material produced by the students during the group work session was collected. Nineteen video-recording sessions were conducted on which a total time of 435 minutes and 52 seconds were spent. These sessions involved a total of 15 mathematical topics and the participants attempted 103 tasks. We chose to video record the sessions as video data allow the researcher, “to re-visit the aspect of the classroom” through which “greater leisure to reflect on classroom events” was gained (Pirie, 1996, n.p). A sequence of seven interacting, non-linear phases of Powell et al. (2003) model was used to analyse the video data. During the *coding* phase all critical episodes were analysed employing the mathematical communication framework (Figure 1). That is to say that for each episode we carried out both analysis of the cognitive learning strategies of the SRL model (which produces a grid of strategies associated to parts of the transcript) and using discourse analysis tools from Sfard and Kieran (2001).

4. Data analysis

For the purpose of this paper, we select the donkey problem (Fig. 2) as an exemplification of students’ interactions and their engagement with the SRL strategies. This exercise was set to the students as part of a lesson on geometric loci. The students were given the diagram in Fig. 2 and asked to find the location of the treasure. The content of the lesson was on constructing the locus of a point which moves according to a rule. Students were taught to find the locus of a point that moves according to a simple rule including a given distance from a fixed point, a given distance from two fixed points, and a given distance from a fixed line.

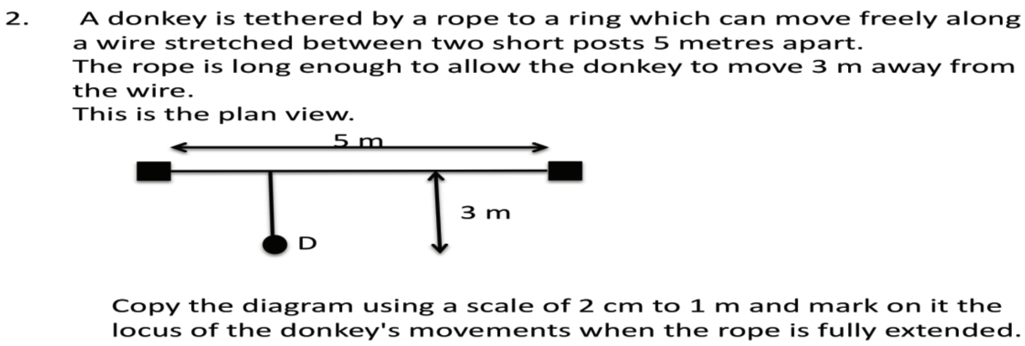

Fig. 2. The donkey problem

The following conversation was recorded (time: 00:05:20 – 00:10:48):
Kathy reads the problem aloud.
[1] Sandy: The ends can go around.

[2] Anne: Oh no, it can only around (pointing at the end of the rope attached to the wire). What you need to do is… draw 3 m here (using her finger to show how to draw it), and put the post there (using her finger to show where to draw the post).
Sandy copies and draws the line between the posts according to the scale given with the help of Kathy and Anne.
[3] Anne: It's actually two big circles there.
[4]Sandy: It does not make two big circles. It's a line, then a circle, a line, and circle (using her finger to show).
[5] Kathy: Here it is. This is attached to my finger and it can move across it, so it's a line (Kathy is demonstrating the donkey's movement along the wire using her finger and pen).
[6] Sandy: The rope is long enough…the wire (reread the sentence from the task). 3 m along the wire (stressing on the phrase).
[7] Anne: So you need to do it 6 m down the line and then round (using her finger to draw).
[8] Sandy: That's what I am going to do.
Sandy draws the required locus of the donkey's movements.

5. Discourse analysis and cognitive learning strategies

Table 1 focuses on the participants' tripartite focus employing the focal analysis in order to examine the effectiveness of the participants' interactions. Preoccupational analysis is used to determine the productiveness of the participants' interactions through the interactivity flowchart, Fig. 3.

Table 1. The participants' tripartite foci of the donkey problem

Sandy			Kathy		
Pronounced Focus	Attended Focus	Intended Focus	Pronounced Focus	Attended Focus	Intended Focus
[1] go around	Diagram	At the posts			
[4] circle and a line	Diagram	At the posts and along the wire	[5] a line	Diagram	Along the wire

Anne		
Pronounced Focus	Attended Focus	Intended Focus
[3] big circles	Diagram	At the posts

Sandy argues that the donkey can go around at the posts as she states, "*The ends can go around*" [1] clearly emphasising the donkey's movements at the posts. Table 1 shows that the phrase 'go around' is Sandy's 'pronounced focus' which is relevant to the requirement of the task. The 'pronounced focus' suggests that Sandy recalls her knowledge on the locus of a moving object at a point when she demonstrates the donkey's movement at the posts. Thus, this suggests that Sandy is engaged with the rehearsal strategies: evoke prior knowledge relevant to the problem. Table 1 also shows Sandy's 'attended focus' is directed to the diagram. The 'attended focus' implies that Sandy is gathering information from the diagram, in this case relating the post to a point. At this moment, Sandy's attention is focused on how an object moves at a fixed point. The act of 'gathering information' suggests that Sandy is engaged with the organisational strategies. Table 1 shows that Sandy's 'intended focus' is at the posts which implies that Sandy's intention is to find the donkey's movement at the posts. This shows that Sandy is observed to provide opportunities for others to regulate their learning. The preoccupational analysis shows that Sandy's utterance [1] is observed to be an interpersonal channel of object-level communication as shown in the interactivity flowchart, Fig. 3, which implies that she is proposing her idea to others in a mathematical way. At this point, Sandy attempts to bring the group to focus on the donkey's movement at the posts. However, in response Anne is observed to focus on the end of the rope attached to the wire and not the posts as she states, "*Oh no, it can only around*" [2]. Although Anne recalls her prior knowledge of locus (the same as Sandy) her prior knowledge is not relevant to the requirement of the task. Thus, Anne is observed not to engage with the rehearsal strategies. In the context of the donkey movement, the focal analysis shows that Anne's 'pronounced focus' is 'around' however this does not reflect the donkey's movement at the posts. This contradicts what is required of the task. The analysis also shows that Anne's intention differs from the aim of the task. Consequently, Anne's tripartite foci are not relevant and are not represented in Table 1. This suggests that the exchanges between Sandy and Anne are incoherent as they talk about different subject matters. From the interactivity flowchart, Anne's utterance is of interpersonal channel of non-object level communication as she is talking about something that is not relevant to the task. Thus, the overall situation involving exchanges [1] and [2] suggests that the interaction is non-effective and unproductive. In the next three utterances, from [3] to [5], the focal analysis shows that the participants share a common 'tripartite foci' as shown in Table 1. The participants' interactions are observed to be coherent. This suggests that the participants are involved in an effective discourse. The interactivity flowchart in Fig. 3 demonstrates that the participants are

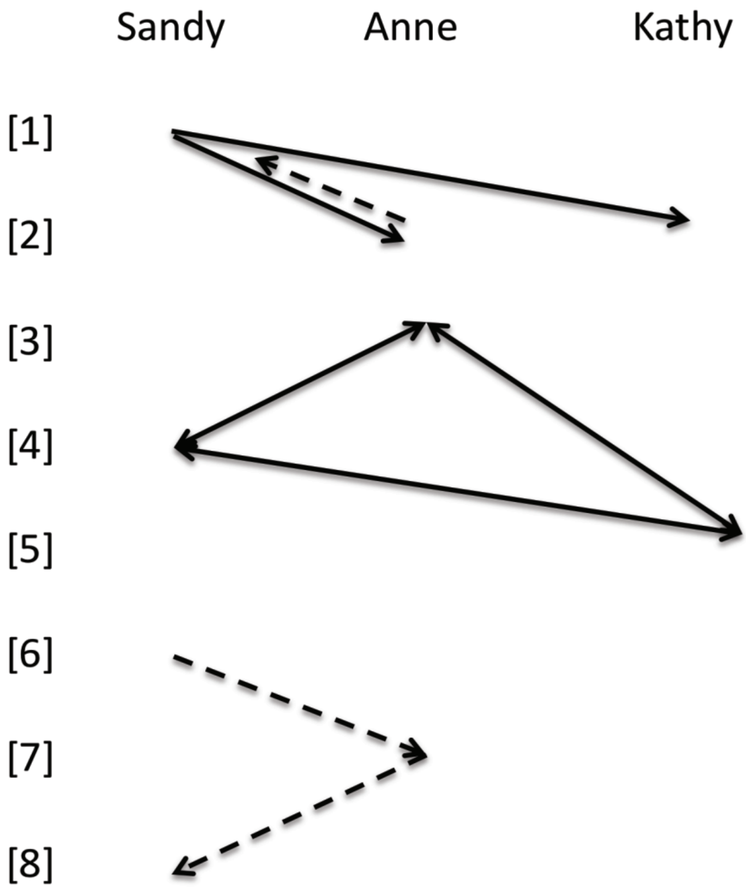

Fig. 3. Interactivity flowchart of the Locus problem

interacting through interpersonal channel of object-level communication which implies that they are interacting with each other mathematically. This indicates that the participants are discussing the task to clarify goals of the task. Thus, this implies that the participants are engaged with one of the characteristics of the elaboration strategies: discuss the problem to clarify goals of the problem. From the interactivity flowchart, the exchanges from [3] to [5] are observed to form a closed triangular shape indicating that a productive discourse is developing at this particular moment. Moving within the group level, the participants are also observed to engage with the rehearsal strategies: evoke prior knowledge relevant to the problem which links the utterances from [3] to [5] together, developing the interactions into a mathematical and a productive discourse. For example, Anne believes that the donkey will move in a circular path at the posts. Anne notes that, "*It's actually two big circles there*" [3] implying she is using her prior knowledge of locus at a point (an object moves in a circular motion from a fixed point) attempting to confirm and clarify the donkey's movement at the posts. At this point, Anne's 'pronounced focus' referred to 'big circles'. Anne's utterance is observed to be a pro-action utterance as it invites responses from others in the group. This can be seen through the interactivity flowchart, Fig. 3, where Sandy and Kathy are responding to Anne and also at the same time proposing their own ideas. Sandy notes that, "*It's a line, then a circle, a line, and a circle*" [4] which shows that Sandy's solution to the problem is that the donkey will move in a line with the same distance above and below the wire. Sandy uses her prior knowledge of locus of a moving point from a fixed point and from a fixed line which enables her to obtain the donkey's movement. At this moment, Sandy is observed to work on the whole task that is finding the donkey's movements at the posts and along the wire. The focal analysis shows that Sandy's 'pronounced focus' is 'circle and the line'. In clarifying Sandy's suggestion, Kathy illustrates the donkey's movement along the wire using her finger and pen and clarifies, "*Here it is. This is attached to my finger and it can move across it, so it's a line*" [5]. Thus, this shows that Kathy, like her friends, has the knowledge of locus of a moving point from a fixed line. Kathy's 'pronounced focus' is observed to be 'a line'. In these exchanges, the focal analysis shows that there are two 'pronounced foci' involved. The first one involves 'circle' whereby Anne [3] and Sandy [4] are focusing on the donkey's movement at the posts. This is supported by the fact that Anne and Sandy share the same 'intended focus' which means that they have the same intention to find the donkey's movement at the posts as shown in Table 1. The second pronounced focus is 'a line' involving interaction between Sandy [4] and Kathy [5] in determining and explaining the donkey's movement along the wire. Table 1 shows that Sandy and Kathy share the same attended and intended focus. Their 'attended focus' is directly connected to the diagram which they utilise in seeking the donkey's movement with the intention to find the donkey's movement along the wire.

Utterances from [6] to [8] demonstrate the interactions between Sandy and Anne in order to construct the donkey's movements as they have discussed earlier. These exchanges are observed to have no further impact towards the discourse in general. This is further explained through the interactivity flowchart where Sandy and Anne interacting are not mathematically. No elements of cognitive learning strategies are observed at this point.

6. Discussion and findings

In the donkey problem, discourse analysis indicated that the participants were involved in an effective and productive discourse. This can be observed during the exchanges from [3] to [5] involving all the participants. The focal analysis showed that the loci 'circle' and 'a line' were observed to become the participants' 'pronounced focus' throughout the discussion and enhanced the development of a successful mathematical discourse among the participants. In addition, the participants shared the same 'intended focus' that was to find the donkey's movements at the posts and along the wire. This was well supported by the preoccupational analysis as the interactivity flowcharts showed the participants' interactions formed a closed triangular shape. This suggested that not only were the participants interacting mathematically with each other but also the interactions were meaningful and the participants understood what others were trying to convey. During this effective and productive discourse (exchanges from [3] to [5]), analysis also showed that the participants were engaged with the cognitive learning strategies. First and foremost, the participants were engaged with the elaboration strategies whereby they were discussing the problem to find the donkey's movements as shown in the interactivity flowchart (Figure 3). The pro-action and re-action utterances implied that a productive discussion was going on between the participants. In the discussion, the participants were applying their prior knowledge of properties of locus which saw them engaged with the rehearsal strategies. This was supported by the emergence of two 'pronounced focus' that were used throughout the discussion. The focal analysis suggested that the participants were also engaged with the organisational strategies: gathering important information from the diagram relevant to the task, and in their discussion the participants' 'attended foci' were directed towards the diagram as a source of information to help them in the task. To summarise, from the analysis showing the group shared a same common focus in finding the donkey's movements at the posts and along the wire (effective discourse) and that the discourse was mathematically meaningful (productive discourse), the participants were likely to engage with the group SRL particularly the elements of cognitive learning strategies.

7. Conclusion

The main contribution of this paper is the mathematical communication framework, as shown in Fig. 1 that can provide more information on students' mathematical discourse and students' SRL strategies. The mathematical communication framework offers a combination of two perspectives, discourse analysis from the socio-cultural perspective and cognitive learning strategies from the social cognitive perspective. With these features, the framework is perfectly relevant to the school mathematics context to to examine students' engagement with the SRL strategies through mathematical discourse while working on a mathematical task.

References

Kieran, C. (2001). The mathematical discourse of 13-year-old partnered problem solving and its relation to the mathematics that emerges. *Educational Studies in Mathematics, 46*(1-3), 187 – 228.

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Reston, VA: NCTM.

Pintrich, P. R. (1999). The role of motivation in promoting and sustaining self-regulated learning. *International Journal of Educational Research, 31*(6), 459 – 470.

Pirie, S. E. B. (1996). Classroom video-recording: when, why and how does it offer valuable data source for qualitative research? *Proceedings of the 16th Annual Meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education*. Panama City, Panama.

Powell, A. B., Francisco, J. M., & Maher, C. A. (2003). An analytical model for studying the development of learners' mathematical ideas and reasoning using videotape data. *Journal of Mathematical Behavior, 22*(4), 405 – 435.

Ryve, A. (2004). Can collaborative concept mapping create mathematically productive discourses? *Educational Studies in Mathematics, 56*(2/3), 157 – 177.

Sfard, A. (2001). There is more to discourse than meets the ears: looking at thinking as communication to learn more about mathematical learning. *Educational Studies in Mathematics*, *46*(1-3), 13 – 57.

Sfard, A., & Kieran, C. (2001). Cognition as communication: rethinking learning-by-talking through multi-faceted analysis of students' mathematical interactions. *Mind, Culture, and Activity, 8*(1), 42 – 76.